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LIMITING FACTORS IN THE MECHANIZATION OF MINES UNDER CONDITIONS PREVAILING IN LESS DEVELOPED AREAS

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A.5.2.3. LIMITING FACTORS IN THE MECHANIZATION OF MINES UNDER CONDITIONS PREVAILING IN LESS DEVELOPED AREAS.

by

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MINISTRY OF MINES AND FUEL

INDIA

Need for mechanisation

1. The majority of the underdeveloped countries of the world have launched programmes of planned economic development with the object of increasing the national income and the living standards of their peoples. Rapid advances in the standard of living and the production of consumer goods will be possible only after a solid foundation of heavy industry, transport and power resources is laid. These in turn are based on mineral raw materials such as coal, iron ore, oil, metallic ores etc. Thus the speed with which the development programmes can be implemented is intimately linked with the speed with which local mineral resources can be exploited. It is in this context that the need to mechanise mines has to be examined, since under certain favourable conditions mechanisation results in the speedy execution of mine development and exploitation programmes, often resulting in the saving of 1½ to 2 years in the deferment period.

2. Mechanisation also results in higher rate of production and increase in output per manshift with a consequent increase in the earnings of the mine workers. The extent to which the output per manshift may be increased depends upon a variety of factors such as the level of industrialisation in the country, the availability of skilled personnel and mode of occurrence of the deposit.

3. A reduction in the unit cost of operation is also achieved by mechanisation, but only when a number of important conditions are fulfilled. The main advantages of mechanisation are concentration of operations with consequent reduction in supervision cost, higher output, high OMS and large production from limited areas. But these advantages accrue only when the equipment used is of the right type for the job, it is operated effectively at the rated capacity, is never allowed to unnecessarily idle either for shortage of power, spare parts or servicing and maintenance facilities. The need for effective coordination in the various phases of mining operations, ore handling and preparation cannot be over emphasised. Another important consideration is the matching of the various types of equipment to be used for the different jobs. Even if the right equipment is selected for each of the interlinked operations per se, a mechanisation programme may still fail for want of co-ordination between the various phases.

4. The capital expenditure in the development of large mechanised mines is very high. In India, it is of the order of Rs.50/- per ton of annual output in the case of coal mines, involving a capital outlay of Rs. 50 million for a mine

designed for an annual production of a million tons. If the machines work at their rated capacity, the expense on account of depreciation and interest charges at a rate of 15% will work to about 7.5 million rupees or Rs. 7.50 per ton. If for any reason the machinery works at only 50% of rated capacity the fixed charges will increase to Rs. 15 per ton, thus rendering the entire mechanisation scheme uneconomical. The National Coal Development Corporation in India have procured a 15 cu.yds. dragline for the opencast mine in Kurasia and will soon have four more, the largest of which has a bucket capacity of 39 cu. yds. and costs Rs.10.5 million. The substantial financial losses which may arise if they are not kept operating at their rated capacity is obvious.

5. Since electrical energy requirements are also large in mechanised mines and form an important item in the cost of production, the cost at which it will be available has also an important bearing on the likely unit mining cost.

6. Often, instead of total mechanisation, partial mechanisation of certain unduly labour wasteful operations may well result in a reduction in unit operating costs. Such schemes of partial mechanisation have been successfully implemented in Singareni Collieries in India. Similarly partial or complete mechanisation may prove successful in certain particularly well developed areas in a generally underdeveloped country, while elsewhere perhaps more labour intensive techniques may prove cheaper.

7. The development of industries like iron and steel, heavy machinery, electrical machinery etc. will create excessive internal demands for minerals in a finished or semi-finished state, necessitating mine mechanisation to meet increased demands. As minerals in a semi-finished or finished state acquire many times their value in the raw state, creation of mineral-based industries in a country will result in generating the additional wealth necessary to defray the cost needed for mine mechanisation.

8. As an alternative to mechanisation, the increasing requirements of minerals can be obtained by greatly increasing the number of workers employed. But the substitution of labour intensive techniques does not do away with the need for additional capital expenditure or operational costs, since progressive labour welfare legislations in various underdeveloped countries entail the spending of large amounts of money to discharge those obligations. One of the main reasons for mine mechanisation in underdeveloped countries like India has been this additional need for capital and operational expenditure even when labour intensive methods are employed. In India, whereas the value of mineral production in 1960 showed an increase of more than 25% compared to 1956, due to increased mechanisation, the increase in the number of workers was only 3.5%.

9. Since most of the mining operations are hazardous and require working under conditions of great hardship for the men employed, such as excessively high temperature, humidity, constrictions in working space, artificial light, inadequate ventilation, etc., substitution of machines for men in such hazardous occupations will be very desirable.

Mechanisation vis-a-vis Labour - Intensive Techniques

10. Although speedy industrialisation makes mine mechanisation desirable, the requirement for mechanisation in general and the nature of mining investment in particular impose certain limits on the practicability of increasing mineral production through mechanisation.

11. Mine mechanisation schemes require large capital investments not only for the mine, mill and smelter but often for the development of transport, handling and power facilities. A programme of iron ore development in India, for instance,

includes, among other items of capital expenditure, construction of about 320 Kilometres of broad guage rail road, capable of handling 6-10 million tons of ore every year through a difficult hilly terrain. The order of capital required for mechanised iron ore mines in India is Rs. 50 to 60 per ton of annual finished product, excluding capital required for rail road, harbour and port facilities which may often far exceed the capital required for the development of the mine alone.

12. Another important point is that whereas in certain industries mechanisation results in improvement and standardisation of the quality of the product, mine mechanisation actually results in the lowering of the quality of the ore produced. Since mechanisation is not amenable to selective mining or picking, often barren masses within an orebody have to be mined along with the ore, necessitating the installation of beneficiation plants. As mechanisation results in concentrated large outputs, such beneficiation processes also need to be mechanised, thereby entailing additional capital for suitable beneficiation plants.

13. There is also a diminution in the size of the mine product obtained by mechanised mining. The intensive blasting, mechanical loading and crushing which are the features of mechanised mining result in excessive fragmentation of ore creating a number of new problems. In coal mines the production of dust greatly increases the risk of explosions, requiring additional expenditures on measures to suppress it. Fines of iron ore, and manganese ores require to be sintered, briquetted, agglomerated, or pelletised before they can be marketed, thereby requiring additional capital for such plants.

14. Further capital expenditure on mining investments are inflexible. No two mines possess identical conditions of mining. The mining equipment designed for an orebody of a certain type may not be suitable for efficient deployment in the mining of another ore-body. Similarly processing equipment suitable for ore from one mine may be unsuitable for ores from another.

15. On account of the particularly inflexible nature of mining investments, it is essential to ensure that the degree of risk is low in such investments. Yet mining investments generally involve a higher degree of risk than other industries. Uncertainties regarding shape, size, extent and tenor of ore bodies, unpredictable price fluctuations, possible technological advances which may render established plants obsolete, shifts in demands arising out of development of substitutes, changes in international politics and national policies all add considerably to the risks of mine investments. It is possible within limits to reduce such risks by well directed programmes of mineral exploration. But such work is costly and time consuming and increases the deferment period considerably. A desire on the part of mine investors for a higher rate of return on investments and quicker rate of return of the invested capital is thus quite understandable.

16. There are certain types of mineral deposits which on account of their shape, size or mineralogical distribution, are not suitable for mechanisation. A large number of mica mines in India fall into this category. This also is a case with small mines with very low production from small reserves.

17. A very vital factor in underdeveloped countries is the prevalence of high unemployment and under-employment. Increases in population aggravate the problem. In India it has been estimated that the unemployment figure at the beginning of the Third Plan period was 9 million. Even if the plan works out according to schedule and provides employment opportunities for an estimated 14 million, the backlog of unemployment at the beginning of the Fourth Plan would be 12 million. It is against this disquieting background that schemes of industrialisation have to be examined.

18. Direct employment opportunities in relation to the capital invested varies widely from industry to industry. The capital required per person employed is of

the order of Rs. 160,000 for steel, and Rs. 100,000 for a heavy machine building plant, while it is only Rs. 11,000 for newly opened mechanised coal mines and Rs.20,000 for partially mechanised copper mines. Mechanised mining is thus comparatively labour intensive. At the same time, the labour employment potential of non-mechanised mines per unit of investment is very much higher. It is desirable to retain this characteristic of non-mechanised mines unless, of course, other overriding considerations favour mechanisation in special cases. Coal, oil and minerals capable of earning or saving foreign exchange can reasonably be included in this category. This in the long run may provide far greater employment opportunities by quickly building up a base for consumer goods industry.

19. Present trends in mine mechanisation favour development of large units of production as these are more economical than smaller units. As the basis of economy is the continuous deployment of equipment at their rated capacities, modern mechanised mines entail large concentrated outputs. Obviously, such schemes will not succeed if the transport facilities are inadequate.

20. Mechanisation makes great demands on power. The availability of adequate power and the rate at which it can be made available at the mine are, therefore, important factors in the feasibility and success of mechanised programmes of development. For instance, a diesel power station installed exclusively to meet the requirements of a mine, the cost of electric power at an estimated requirement of 30 units per ton of ore produced may be as high as Rs. 7.50 per ton. When the mines are located within economic transmitting distance of a public utility Co. supplying electricity, the corresponding power expenses may be only Rs. 1.50. It may thus be advisable to mechanise the mining operations in relatively well developed areas of an underdeveloped country, while in the remoter areas, the factor of power alone may render manual mining operations more economical than mechanisation.

21. Mining like any other industrial project requires considerable number of technical and skilled personnel during the various stages of planning, design, erection, maintenance and operations. Thus in a mining project, a large number of engineering and technological personnel of various categories, of considerable experience and competence are required in the planning stage in order to prepare a project report, study in detail its economics, technical aspects and its erection there-after. Whereas their services in any mining scheme are required only at the project stage, personnel incharge of operation and maintenance will be responsible for the continued efficient operation of the plant throughout the life of the mine. While the number of skilled personnel required for operation is generally higher than that required for maintenance, the degree of skill required for operation is lower and can be acquired in a shorter period. Skill and knowledge of maintenance, however, are more difficult to acquire and take more time. Since the number of such men needed for an individual project is small it is easier to arrange for necessary training facilities for this purpose. It may be advisable to associate 10 to 15% of the future requirements of the key personnel for maintenance at the erection stage itself. The policy of entrusting erection to a certain group and allowing the taking over of the plant by an entirely new group of maintenance and operational men is not good for obvious reasons. As in all underdeveloped countries the know how of modern equipment is very meagre it is very desirable to attach a large number of local engineering personnel of various categories with foreign consultants who can train them for various jobs during planning and construction period.

22. The type of personnel selected for such training is also important. While the persons selected should have adequate and sound technical background and training it is advisable to choose comparatively young men so that the benefit of their training can be made available to the country for a long period. Almost all the underdeveloped countries would welcome the assistance of foreign experts for training their local personal. Unfortunately while requesting for such assistance the underdeveloped countries are not specific for the requirements with the result that

in many cases such opportunities are not fully utilised and a foreign expert visits a number of places or institutions in the country and offers suggestions of a general nature which are not of much help either in the training of personnel or in the development of natural resources.

Conditions Prevailing in Under-developed Countries

23. All under-developed countries are faced with the problem of inadequate capital and a very low rate of capital growth. Resources of private capital are small, obliging governments to take on increasing burdens of investments ranging from 30% to 60% of the total outlay in various countries.

24. Foreign exchange required for the purchase of plant and machinery, spare parts and payment to foreign consultants and foreign nationals employed in the design, execution and operation of various projects is often very large. For instance, the foreign exchange requirements of India in the Third Plan mineral development schemes alone is Rs. 288 crores out of total investment of Rs. 766 crores. The foreign exchange resources of under developed countries are very low and they have to largely depend on foreign aids to implement their development plans and programmes. The best means of raising foreign exchange in under-developed countries is by launching upon determined export drives for indigenous products, restriction on domestic consumption of export earning commodities, increasing the profitability of exports by maintaining a competitive price for export products and high productivity. This means that capital should be made available for industries which have good export potential.

25. Expenditure on foreign exchange required for employment of foreign nationals can be reduced by introducing well thought out training programmes. Expenditure for machinery, plant and stock can be reduced, provided the available natural resources, permit, the development of machine manufacturing industries in the country. The foreign exchange required during the development stage has necessarily to be obtained by external assistance and by creating a favourable atmosphere for the in-flow of private foreign capital.

26. One of the greatest obstacles to the speedy development of mine mechanisation is the non-availability of mining machinery. The total requirements of mining machinery for the Third Five Year Plan of India amount to more than 410 millions of rupees, the bulk of which has to be imported from abroad, since manufacturing capacity within the country is either lacking or inadequate.

27. Rapid development of mineral resources demand the services of a great number of qualified technical personnel competent in various branches of science, engineering and technology. But gross inadequacy of trained personnel is a feature in most of the under-developed countries of the world. There is almost complete absence of men capable of performing the duties of planning and designing for the various stages of operation pertaining to the exploitation of mineral deposits. The short fall in the requirement of such trained personnel as of necessity involves the calling of technicians from the industrially advanced countries of the world thereby imposing a considerable strain on the foreign exchange position of most of the under-developed countries of the world.

28. It has already been emphasised that a detailed knowledge of an orebody is essential before the heavy capital investments of mine mechanisation can be incurred. Unfortunately, the state of knowledge regarding the mineral resources in under-developed countries is wholly inadequate. It is necessary that the national resources of minerals should be ascertained to decide if it is desirable to allow export of any mineral product in large quantities in order to acquire foreign exchange and specific prospects will have to be explored in detail for the production of the magnitude considered admissible. The problem thus is to make a rapid appraisal of

the local mineral resources and to take up detailed exploration of attractive mineral prospects to bring about production quickly.

29. Though the importance of mineral exports as a source of foreign exchange is well realised, exploitation of such resources is inadequately done mainly because of the lack of adequate knowledge of the resources of the under-developed countries. This generally tends to favour conservation of minerals by withholding production for export as much as possible, because of the fear that export of such minerals may result in the impoverishment of the under-developed country. A rational use of national mineral resources may however call for the export of mineral raw materials to the industrially advanced nations requiring such minerals in exchange for the much needed machinery, plant and foreign exchange.

30. Scope for Mechanisation of Mines in Under-developed Countries

30. Though the characteristics and requirements for successful mine mechanisation and the unfavourable conditions prevalent in under-developed countries militate against mechanisation, yet it is justified under certain conditions.

31. Only mineral deposits containing large reserves are capable of sustaining high rate of production. If the shape, size and extent of orebodies are such that large tonnages have to be produced from a limited space, it would be advantageous to mechanise mining operations. For example, a deposit with a width of 100 ft. and an exposed outcrop running over 10,000 ft. may contain the same amount of reserves as another one whose dimensions may be of the order of a 1000 ft. by a 1000 ft. In the former case, it is possible to produce the required tonnage with a limited degree of mechanisation, while in the later it will require to be completely mechanised to obtain that out put.

32. In cases, where there is a need to quickly raise large tonnages of ore, mining schemes may be mechanised provided the over all profitability is substantial. Fuel minerals like coal which are essential for development of any industry and minerals which will generate foreign exchange because of their export value or their ability to act as substitutes for essential imports would come under this category.

33. A large mining project requires about 4 to 5 years for bringing it to full production; if the period of preliminary exploration is included it may be as long as 7 to 10 years. Often certain types of ore deposits can be fully assessed only after extensive underground exploratory programmes. It is often possible to speed up underground exploratory operations by substantial mechanisation using suitably designed equipment available in the market. If the mine required the erection of a mill and smelter, then it is good practice to ensure that the production from the mine starts about 6-months before the mill can function and attains peak production at about the same time that the mill and smelter are ready for working. If it is estimated that the period for development and stope preparation by semi-mechanisation required for full production exceeds the time required for the erection and operation of the mill and smelter then there is a strong case for mechanisation of the whole of the development operations. Development of mines where the erection of mill or smelter are not required should be completely mechanised as this will undebtedly bring the mine to the level of production atleast 1 to 2 years earlier, depending on the volume of work required. In India such cases may arise in the development of coal, Iron ore and Manganese ore mines required to be developed for purposes of exports of these ores.

34. In every mine there are certain phases of mining operations which are unduly wasteful of labour and impose considerable hardship and fatigue on the men employed. Such phases are dewatering, blast hole drilling, ore hoisting and long distance manual transport. These operations should invariably be mechanised in all cases. There is a great scope of mechanisation of such operations in underdeveloped countries.

Trend in Mine Mechanisation in India.

35. There has been a great increase in the quantity and variety of mineral production in India in recent years. Rapid strides have been made in India in extensive and intensive programmes of mineral exploration and as a result the knowledge of mineral resources of the country is now more clear and precise than before. In actual mining operations, there has been a shift from the traditional method of manually operated mines to the development of large mechanised units. The entire production of coal in the public sector is to be obtained from a small number of intensively mechanised mines with large individual outputs. The number of coal mines with an annual production of 300 thousand tons was only six in 1946. Compared to this, the National Coal Development Corporation of India alone has plans for the development of seven coal mines each capable of producing about a million tons of coal every year. The total production of iron ore in 1946 was 974,000 tons. At present atleast 4 large iron ore mines have plans for an annual production of 2 million tons each every year, equivalent to a daily production of 10,000 tons of R.O.M. ore. These have reached various stages of development. In the development of coal mines referred to above, the Civil Engineering work taken up during the Second Plan Period amounted to Rs. 10.19 crores, equivalent to 30% of the total amount estimated for the projects. Power shovels with capacities of $2\frac{1}{2}$ cubic yard to 8 cubic yard with 5 to 6 dumpers for each shovel are being used. In the Kursia open cast coal mines, it is proposed to employ a drag line of 15 cubic yard capacity. Four more drag lines, the largest of which has a bucket capacity of 39 cubic yards (cost 10.5 million rupees) have been ordered for the open cast mines at Bisrampur in Madhya Pradesh and South Balanda in Orissa.

36. The lignite operations at Palana envisages the removal of 69 metres of over burden by large capacity bucket excavators to expose lignite bed of about 3 to 6 metres thick. Another important mechanised mine under development is at Neivali, at Madras, which envisages the utilisation of large capacity bucket excavators for the mining of lignite. Iron ore mines being developed by the Public Sector, have plans, for large production through mechanisation. The Mines at Rajhara, Kiriburu and Barsua, each with a target production of 2 million tons of sized ore annually have reached various stages of development. In the Private Sector, the Gua Iron ore mines have been fully mechanised from the face to loading point for an annual production of 2 million tons. Similar mechanization programmes have been introduced in the Noamundi iron ore mine of Tata Iron & Steel Co. and the Bolani iron ore mines of Bird & Co. The number of coal cutting machines has increased from 359 in 1949 to 696 in 1960, similarly the aggregate H.P. of electrical plant used in mining increased from 160,000 in 1949 to 500,000 in 1960. After coming into production of the Heavy Mining Machinery Plant at Durgapur and the Heavy Electrical Plant at Bhopal(now under construction) and the successful implementation of the various programmes of training now being lauched by the Government, mine mechanisation is likely to extend to a large number of other mines in the country.

Programmes and Measures for the Implementation of Planned Mine Mechanisation

37. The manufacture of mining machinery is obviously an important requirement for the successful implementation of mine mechanisation programmes. The main advantage of local manufacture of such machinery is that the drain on foreign exchange will be greatly reduced also removing the necessity for maintaining large stocks of spare parts.

38. The Government of India has set up a Heavy Engineering Corporation for the manufacture of equipment required for steel making, heavy machine tools and such machines as coal cutters, loaders, conveyors, mine locomotives etc. The total capacity expenditure is of the order of about 180 crores for a scheduled annual

production target of 260 thousand tons of such machinery. The Heavy Machinery Plant at Ranchi in Bihar, after its target of production of 80 thousand tons in y year is reached, is expected to cope with the demands for the bulk of the equipment required for adding to the country's steel making capacity at the rate of one million tons per year. The production of 45 thousand tons of mining machinery will also substantially meet with the heavy machinery requirements of the coal mining industry. Similarly after programmes of manufacture of heavy electrical equipment such as heavy duty generators, motors, transformers etc., are achieved, the country is expected to be largely self-sufficient in these items.

39. The importance of providing training facilities has already been emphasised. At the begining of the Second Plan, there were only two institutions in India imparting instruction in Mining Engineering of a degree standard. The capacity of these institutions has since been greatly increased and additional courses for mining engineering have been started in six other colleges and technological institutions. The State Governments are establishing fourteen institutions for the training of subordinate personnel required in the mining industry. It is expected that these steps will ensure that the bulk of the additional personnel requirements of the mining industry, estimated at sixteen hundred engineering graduates and four thousand diploma holders, will be met.

40. The purpose of mechanising mines is defeated if there are transport bottlenecks, power shortages. Therefore the development of power and transport and mine mechanisation programmes should move hand in hand. The objectives in this regard should be, to encourage regional development and also different modes of transport rail, road and water. In India the concentration of coal production in Bengal and Bihar coal fields has posed serious problems in transport and power shortage. A solution of these problems is being attempted through simultaneous action in the development of outl-ying coal fields, transporting coal by road and also by water ways.

41. Under-developed countries may simultaneously consider the establishment of metallurgical industry, Electrical Engineering Industry and Chemical and other allied industries. This will increase the indigenous consumption of minerals and metals thereby greatly strengthening the domestic mining industry. Another profitable step will be the installations of a few custom mills and smelters which may often enable a large number of small deposits in a mineral district to be economically exploited.

42. Since any programme of mechanised mineral development calls for an expenditure of substantial amount of capital, with a high foreign exchange component, a favourable atmosphere has to be created for the flow of such capital. The factors which have an important bearing on the formation of both domestic and foreign capital are mining mineral laws of the country the taxation policy of the local government, the political stability of the country and its policy on nationalisation, facilities for repatriation of income and investment and laws pertaining to the formation and operation of companies etc. They must all be liberalised to attract foreign capital and technicians.

43. In India in order to encourage the formation and investment of capital for various industrial development schemes, the Government have introduced a number of incentive schemes such as exemption from income-tax during the initial years of a company's activities, liberalisation of depreciation allowance rate, development rebates on new plants and machinery, provision for exemption from income tax of foreign technicians locally employed etc. Steps have also been taken to ensure guaranted repatriation of foreign capital and avoidance of double taxation, and the most recent one is the formation of a joint company - Manganese Ore India Ltd. in which 49% holdings are of a British Company and 51% of the Central and State Governments.

44. All the under-developed countries have a long tradition of Labour intensive techniques in working mines. Mine mechanization is a new experiment which is likely to present several obstacles, which must be surmounted before those countries are anywhere near the achievement of their goal of industrialisation, raising the standard of living of their people by removing poverty, ignorance and disease and resulting in the creation of a new society in which importance of human values and individuality will be respected.

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